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GAS LIGHT JOURNAL

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THE NEW YEAR.

With this number we commence a new volume and a new year, and it is with the greatest pleasure that we can congratulate the gas industry upon its fairly improved condition when compared with what it has been for a few years past. The general condition of the business of the country is excellent, and the effect is most surely apparent in the increase of business which most of the companies in this country can to day congratulate themselves upon.

During the year just closed, while there have been no very startling changes in the methods employed in gas manufacture, there have been some marked improvements; and these may be found both in methods of handling and in carbonization. One of the leading features of the year's working is the adoption, in several large works, of mechanical stoking, whereby not only the amount of hand labor, but the character of the work to be done by the stoker is materially changed.

The exhausting, scorching work of rushing into a red hot flame, with a hundred weight of coal to lift along, is changed by this means to the simple operation of standing eighteen or twenty feet away from the hot retorts, and manipulating a couple of levers, in the case of drawing charges, and to an equally simple operation in the case of charging.

Nor is this all the improvement resulting from this change. The necessity for hauling the coals quickly, and with facility, has led to the adoption of mechanical means for the handling of the material before it arrives at the machines which, of themselves, will unquestionably result in large economy, not only in the number of men, but in the price to be paid them. And in this way one economy begets another, and to those who are earnestly studying to bring the manufacture of gas down to a practical basis, it has become a question of handling the largest amount of material, with the least possible expense, and then converting that material into the form required in the most thorough and economical manner. On this latter point much study, and doubtless much experiment, is being indulged in to produce a furnace or generator that will carbonize the most coal with the least fuel. Our columns to-day give an account of one of the latest devices for this purpose, and we are confident that the efforts in this direction are only just beginning to take practical shape. The papers and discussions at the meetings of the various gas associations, held during the year, give evidence of a spirit of enquiry in this direction that will doubtless result in devices for securing still greater economy in carbonization.

The subject of residual products is one which has by no means been left out of consideration; and although the matter may not yet have taken definite shape, still a movement is on foot, in the right direction, to secure a return for that which for years has been thrown away. The fact that in England some of the companies secure a return from this source equal to from sixty to seventy per cent. of the original cost of their coal is one that must not be lost sight of. Coke, tar, and ammoniacal liquor are worth money, and "money saved is money made." An examination of the accounts of some of the English companies would indicate that the dividends were paid largely by residuals. The prices for these products are steadily advancing; and, if we are not mistaken, a very few years will see a demand in this country for creosoting purposes alone that will be enormous. The large extent to which wood is used in railway construction, and in street paving, and the fact that no other agent is so good for timber preservation as the creosote from coal tar, will, of itself, create a home market for all there is of this material at remunerative prices.

In the matter of purification, the main novelty during the year is the use of superphosphates for absorbing the ammonia from gas, and, at the same time, yielding not a waste product but a valuable fertilizer. One of the most striking features is that results obtained thus far would indicate a new alliance of the gas maker and the fertilizer manufacture which shall prove useful and profitable.

Of means of illumination other than gas we have the petroleum, which continues to flow in numerous streams from the bosom of the earth, and the price of which to-day is by far too low to suit either the oil or the gas man. The Bradford district, in Pennsylvania, seems defined and slowly diminishing its supply, and the neighboring district in New York state is to-day yielding scarcely enough to make up the decrease; still, too much stock on hand seems to prevent the attainment of the oil man's happiness, viz., a dol-

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lar a barrel for oil. Yet gas is burned more and more, and the low price of oil, though a competitor, is not a preventive against the increase in the annual send-out of well-regulated gas companies.

The electric light continues to occupy much attention, and it is quite encouraging to be able to state that, after the recent exhibition in Paris, many of the most distinguished electricians were known to admit that, after all, electricity would not extinguish gas; but that the two lights would continue side by side, each rendering whatever assistance it may to the other. This is as it should be. It takes all kinds of people to make a world, and why not have all kinds of light to guide them through its dark places—from the tallow dip to the mighty iron tower, which shall illuminate whole cities and their inhabitants, when the belt does not slip or something get out of order. Of the many improvements in electric lighting we endeavor to keep our readers informed, but, as yet, we can see no reason to advise them to give up making good, honest, sixteen candle gas for those who prefer to use it, as we believe that the number of consumers will not materially diminish in the immediate future.

To all who have extended to us their aid, support, and encouragement during the past year we extend our sincere thanks, and indulge the hope that it will not only be continued in the future, but that their influence will be exerted, on all proper occasions, to extend our usefulness by adding to our subscription lists, and our advertising columns, the names of all those whom they know to be interested in the subjects of which we treat, and to which we will continue to devote our best efforts.

Conclusions of the Electrical Congress.

La Lumiere Electrique gives the following as the conclusions adopted by the electrical congress at Paris—

1. The fundamental unit is the centimeter, gramme, second (C. G. S.)
2. The *Ohm* and *Volt* will retain their present values, 10^9 for the ohm and 10^8 for the volt.
3. The unit of resistance (*Ohm*) will be represented by a column of mercury having a section of a square millimetre and the temperature of 0°C.
4. An international commission will determine by new experiments the length of the above column of mercury which will represent the value of the Ohm.
5. The current produced by a Volt in an Ohm is to be called *Ampere*.
6. A Coulomb is the quantity of electricity which would enable an Ampere to give a Coulomb per second.
7. A *Farad* is the capacity in which a Coulomb gives a Volt.

The Society of Gas Lighting.

The Annual Meeting of this Society was held in New York, on December 15th, 1881, and the following officers were elected for the ensuing year:

President—Joseph R. Thomas, Williamsburgh, N. Y.
Vice-President—C. V. Smith, New York city.
Treasurer—J. H. Armington, Brooklyn, N. Y.
Secretary—G. Warren Dresser, New York city.

There were thirteen members present. The annual reports of the officers and the various committees were read, and the usual routine business transacted.

Cooking and Heating by Gas.

Mr. William Denny, F.R.S.E., etc., of Dumbarton, Scotland, read a paper before the Philosophical and Literary Society of that city, on November 21st, upon this subject, which has been published in a neat pamphlet form, in which he treats, in a general way, of the advantages resulting from the use of gas for cooking and heating, and gives some practical results obtained by carefully conducted experiments. The trials were made with different stoves, and also with various forms of grate fires for gas, and the results compared with those from coal. These results are given by carefully constructed charts showing, by means of curves, the results obtained in each case.

Nothing can tend more towards popularizing the use of gas than the dissemination of correct practical information in this way. A lecture by a man known to be entirely disinterested, and who comes to the investigation of the subject simply with a view to obtain the facts in the case, and give them to the public for their information and guidance, is undoubtedly one of the best methods of educating the public; and there are many places in this country where something of this kind might be adopted with great advantage. We feel that Mr. Denny, in his impartial way of treating this subject, has set a most worthy example, and has no doubt accomplished much towards educating the people of his own city, as well as those of other places, in the advantages which they possess by being supplied not only with light but with heat from a source so convenient, so safe, and so reliable as the simple gas pipes within their houses.

Danger from Electricity.

Another illustration has been given of the wisdom of our warning against the needless exposure of the wires used in electric lighting. The accident in Philadelphia last Friday night was one which may have innumerable repetitions, if its cause has been correctly given. It is said that the contact of a telephone wire with a wire used for electric lighting surcharged the former, so that an action like a stroke of lightning was the result, and flames filled the room in which the discharge took place, and they were with difficulty extinguished. It is possible to protect wires used in electric lighting so that such accidents will not happen, and the proper precautions should be taken at the very beginning of the introduction of electric light to practical use.

In cities of Europe the wires for electric lighting are put underground, and it is evident that they should not be strung upon poles in New York. Let the companies make no mistake in this matter. It will be but little more expensive to sink the wires than to hang them upon poles, and it will be far better in the end. The thorough insulation of wires laid in buildings for electric lighting is also a subject calling for the attention of electricians. Their pecuniary loss will be very heavy if their neglect to take proper precautions results in a destructive conflagration. They must not expose our city to the flames by the improper use of wires for electric lighting, either in the streets or in buildings.—*Mail and Express*, Dec. 27.

[Communicated Article.]

Extending the Use of Gas.

By Eta.

This subject has been discussed so frequently and at such length, that it may be claimed, with some show of reason, that the question has been thoroughly ventilated, and there is nothing more to be added which would not be a repetition or condensation of dissertations already published. Still, while admitting that this remark may be in a great measure correct, we think there are points in connection with the subject which have not received the consideration to which their importance entitles them.

One point to be constantly borne in mind is that the grand field which lies open for the extension of the use of gas is in supplying *light*. This remark may seem to be ridiculously superfluous; but so much has been written concerning the supply of gas for cooking and heating purposes that it may be well to bear in mind, at the outset, that, whereas these are all valuable auxiliaries of our business which demand and warrant most careful study, the fact still remains that our main business is supplying light. Gas has been the chief artificial light of the civilized world for more than half a century; for the most part it has performed its mission well, and there does not seem to be, at present, any good reason why it should not continue to be the chief illuminator in the future. This being the case, the main branch of our business should be sedulously fostered, and not left to take care of itself, while we develop its auxiliaries.

How, then, may the use of gas for lighting purposes be extended? Artificial light the world has, and must have, and, putting it broadly, those who do not use gas burn oil, hence it would seem instructive to compare the two competitors, and endeavor to find means whereby some of the business which goes to the oil companies can be induced to flow to the purveyors of gas. But we here meet a formidable obstacle in the cheapness of oil. On the other hand, the cleanliness, safety, and convenience of gas are high recommendations in its favor, which will offset any difference in price, if the disparity is not too great. Let us, then, look at the comparative cost of gas and oil in private dwellings.

Now we will not be far out of the way if we place the cost of maintaining an oil lamp at 65 cents a month—on the average—presuming that good oil is used, costing, say, 23 cents a gallon, such a lamp will give a light of about 10 candles. If we take the case of a small family using five such lamps, the cost will be $3.25 a month. An *equivalent amount of light* could be obtained by the use of three good burners consuming five feet an hour, presuming gas of a little over 16 candle power is being supplied. These three burners, being in use on an average four hours a night, would consume 60 feet of gas each evening, or 1,800 feet a month, costing, at two dollars a thousand feet, $3.60 a month—showing only a saving of 35 cents a month in favor of oil, a difference any householder ought to be willing to pay considering the greater safety, cleanliness and convenience of gas. Many a reader will claim at once that there is some fallacy in these figures, that the difference in the cost of the two systems is greater than that shown. It must, however, be borne in mind that an equal amount of light is stipulated for in each case, and when this condition is lived up to, it will be found that the figures are quite correct. The price of oil may be objected to as high; but the figure is what families, who buy by the five or ten gallons, have to pay for the best oil; and if an inferior quality be used a greater quantity will have to be consumed to get an equivalent light. Moreover, if a poor oil be used, a disagreeable yellow light is the result, no matter how much is used. An equal amount of light is specified in each case. People who use oil in their

houses are usually content with comparatively little light, but when they have gas put in, they must have not merely as much illumination as before, but two or three times as much, whence arises the misconception which exists in regard to the relative cost of gas and oil. If gas companies would take means to bring this matter before oil consumers in practical shape, we might not hear so much about cheap oil light.

Attention must, however, be directed to another matter, for we specify that a good burner shall be used for the gas; and we should also have insisted that a proper globe be employed. These are matters of great importance. Five feet of gas, burned on the one hand through a poor burner, surrounded by an old-fashioned globe having a two inch opening below and a five inch aperture on top, and, on the other hand, the same quantity of gas burned, surrounded by a globe with a five inch opening below, supported by a light frame, give vastly different amounts of light. In the one case you have a miserable, blue, flickering flame; in the other, a steady, white light. But what constitutes a good burner and a good globe? Broadly, it may be said, that lava tip burners are the best; first, because the heat of the flame is not readily conducted away; secondly, because they do not corrode as easily as brass or iron ones. Further, when a moderately high pressure prevails, the burner should contain a check to cut down the pressure, then the tip should be large enough so as to allow the gas to issue gently. With globes, the point to be aimed at is to have the same sized-openings top and bottom. It is certainly very satisfactory to note that the manufacture of the old style globes has become almost obsolete, and gas companies should try and adopt some means for "calling in" these old-fashioned ones. This could gradually be done by companies offering to supply the new pattern at cost price. If, in the office of every gas company, two fixtures, one with good burners and shades, the other with poor ones, each passing the same quantity of gas were exhibited, it would not be long before good burners and globes would be in general use. This once accomplished gas would be held in much greater repute. Another point not to be forgotten is that a good burner does not usually last forever, and it should be seen to that, when worn out, the burners are replaced by new ones.

So far we have alluded to only one competitor of gas, namely, oil; and many readers who are connected with large companies, will say that they know no such competitor; that, in their city, gas is the general lighting agent, and the class who burn oil are not the kind of people the gas company wants for consumers. This is an error we think, and, even in the large cities, oil is used by a vast number of people who would be good customers of the gas company if they could be brought to appreciate that there was not such a vast difference in the cost of the two lights. Within a few years a new means of lighting has been put forward as a rival of gas, and when we consider the skill and capital the new competitor—the electric light—has had behind it, it is not surprising that it has made some little progress, nor would it be safe to say that the advance which it has made has been wholly upon its merits. On the contrary, it was brought to the attention of the world at a time when it was only too glad to bid it welcome, and inquire into its merits afterwards. But as a matter of fact, how much of a competitor of gas is the electric light? Perhaps we cannot answer the question in a word, for its progress has been different in the several cities. In some places, mills and factories that were previously good users of gas, have introduced the new light to take its place. In other cities more or less of the street lighting has been given over to the subtle fluid. But the greater number of the electric lights have been used for advertising purposes, outside stores, etc., where it is hoped a great light will attract a great crowd. Is there any cause for alarm in all this? Most assuredly not. Take the case of factories, etc., and there are a number of instances where the new light has been tried and found wanting, and return made to the older and more reliable light; and as time shows its defects for such uses the number of such lost customers, who return to gas, will vastly increase. Now, in street lighting, has its success been such as to prove that it is to supersede gas, even in the division of the work. In a word, the experience so far has been that it is more costly than gas, and, moreover, is unreliable. Again, the price at which gas is supplied has brought in the companies a good profit, while few, if any, electric light companies have declared heavy dividends. However, the electric light is a novelty, and, consequently, will find many customers for a while, regardless of its cost or defects. This novelty having once worn off, there is no reason why gas should not regain what little ground has been lost; for, in the long run, each system will have to stand or fall by its own merits.

There is one fact which should be carefully noted, namely, that people will not believe that a powerful light can be produced from gas until the fact is practically demonstrated; hence the necessity for gas companies to exhibit large and powerful burners in some of the principal thoroughfares, even if the work has to be performed gratis. The foothold the electric light has obtained has not been from talk alone, but by practical demonstration—perhaps it would be well if we were to learn a lesson from this fact. It is, however, the incandescent system of electric light which some assume will supersede gas. Of course, it is not well to underrate a rival, but, assuredly, the average light obtained per horse power by this system, namely, about 120 candles, and the expense for renewal of lamps, must preclude it from successfully competing with gas, save where money is a minor consideration. It is, however, continually being stated that, in the future, this new system of lighting will be so vastly improved that it will be cheaper than gas.

In reply we can only say that the electric light of the future must be compared with the gas of the future. If improvements are being made in the one system so are they in the other.

As, however, it is impossible to foretell what the future has in store for gas and electricity, it is certainly wise to promote, in every way possible, the use of gas for other than illuminating purposes; it will, therefore, be well for us now to turn to discuss this part of the question. No one can dispute, after a careful study of the question, the adaptability of gas for culinary purposes, but the trouble is to get people to examine into the merits of the question. As in the matter of burners and globes we must bring the idea home to them. This can be done by exhibitions of more or less magnitude. There ought to have been, long before this, an exhibition of gas apparatus in every principal city of the Union, gotten up under the auspices of the local gas company. England sets us an example in this respect which we have been very slow to take advantage of, and the matter should not be any longer delayed. Seeing is believing. Let people once see to what varied uses gas may be put, and they will not be slow to take advantage of it. Even smaller companies who do not feel equal to shouldering the expense of a regular exhibition could arrange impromptu affairs in their own offices. Even if it were necessary to buy outright the various articles to be shown, the investment would not be large; and, further, the goods would, in all probability, be quickly sold after the exhibition.

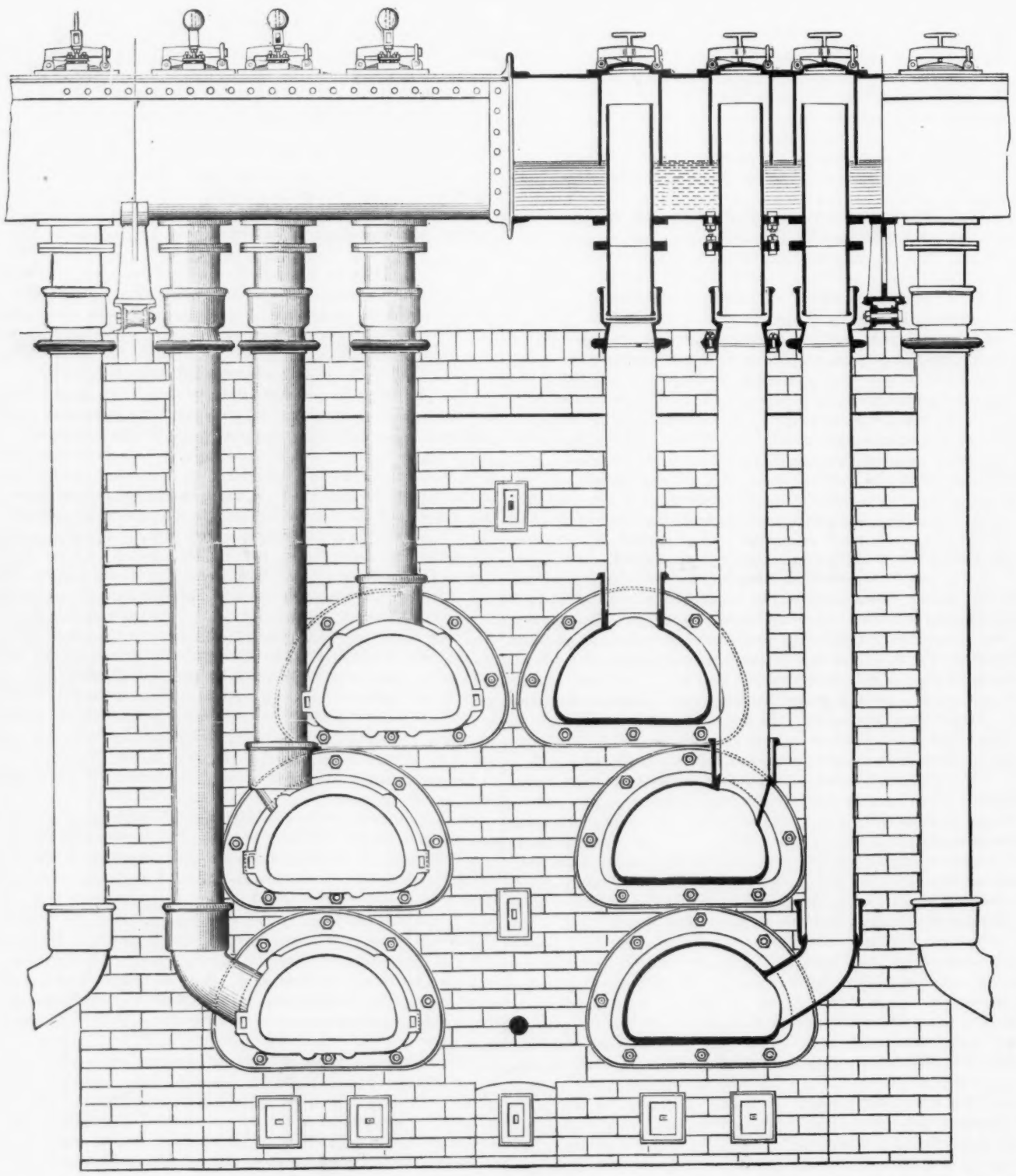
Allowing that people are made aware of the advantages of gas for culinary and other purposes, there are two obstacles to be overcome, viz., the comparatively high price of gas, and the expense of the apparatus itself. The first difficulty has been met, in some cases, by selling the gas, for other than illuminating purposes, at a reduced rate—the question, however, at once arises, is such a course wise? If, for instance, the regular price of gas is two dollars, and the rate for that used in stoves, etc., is one dollar and fifty cents, the consumer is apt to inquire why, if the company can afford to sell gas at the lower figure for one purpose, they cannot do so for another. And there is a grain of logic in the reasoning. How would it do to establish the rule that when the amount of gas used for other than illuminating purposes equalled or exceeded that used for lighting the price of both should be that asked for the gas used for heating? But perhaps the simplest way out of the difficulty would be to make the figure a dollar and fifty all around, and trust to increased consumption to make good the difference. At that price gas would be cheaper for cooking purposes than coal at the current price of five dollars a ton; and even in winter the gas stove might be made to answer by a simple alteration of the heating arrangement of the house, so as to allow of the kitchen being heated as any other room. Further, if the price of gas were brought down to this point the economy of gas engines would soon become apparent.

There still remains the second difficulty, of inducing people to go to the expense of buying gas stoves or engines. This trouble is particularly noticeable in regard to kitcheners, which are quite expensive. The majority of people living in hired houses are disinclined to go to the expense of buying a costly stove, especially if they belong to that numerous and restive class who do not pass two years in the same house; many gas companies have endeavored to meet this difficulty by renting stoves to their customers, charging such a rate for them as will, after allowing for depreciation, bring in a small return on the investment. Some companies have held back from adopting this plan, fearing lest, in case of accident, they would be mulcted for damages, knowing that, from past experience, it is very easy to get a jury to decide a suit against a gas company. The above remarks apply with equal force to gas engines, as there are in every city a number of parties who would gladly pay a rental for the use of an engine, but who cannot afford its first cost. Possibly this whole trouble might be overcome by the formation of a general company for the whole of the States, or separate companies for the several sections of the country, for the express purpose of renting and selling gas apparatus, with an agent in every city where gas is used. If the gas company in any place were unwilling to assume the responsibility of taking the agency they would doubtless co operate with the gas apparatus company, and help it to procure an intelligent representative in its town.

Possibly, this might be adjudged too daring a venture; but if the project were carried out in the right manner, if an effort were made to have the officers of the various gas companies stockholders of the apparatus company, and thus interested in its welfare, there would seem to be good ground for holding the opinion that such a concern might be a powerful agent in promoting the cause we all have at heart, namely, extending the use of gas.

The McIlhenny Recuperator Furnace.

Through the courtesy of George A. McIlhenny, Esq., Engineer of the Washington Gas Light Company, Washington, D. C., an invitation was extended to your correspondent to come and see his new recuperator furnace in actual working operation. The readers of the JOURNAL will remember that during the discussion of the subject of "Generator Furnaces," evoked by the reading of Mr. Greenough's paper on this topic, at the Boston meeting of the American Gas Light Association, Mr. Page gave a somewhat detailed account of the working of the new system devised by Mr.



Front View.

McIlhenny, which description was listened to with the greatest interest. It is not the purpose of this article to attempt to explain the principles involved, or to describe the mechanical working or arrangement of the system in question; but suffice it to say that the air used for combustion is first heated by means of the waste gases from the bench; furthermore, the following figures, taken from the foreman's record-book, give an idea of the practical results obtained in daily working.

The accompanying cuts will give to the reader a pretty clear idea of the construction and arrangement of the bench and furnace itself; and Mr. McIlhenny holds himself in readiness to explain in detail everything in connec-

tion therewith to anyone who may be desirous of further prosecuting inquiries on the subject.

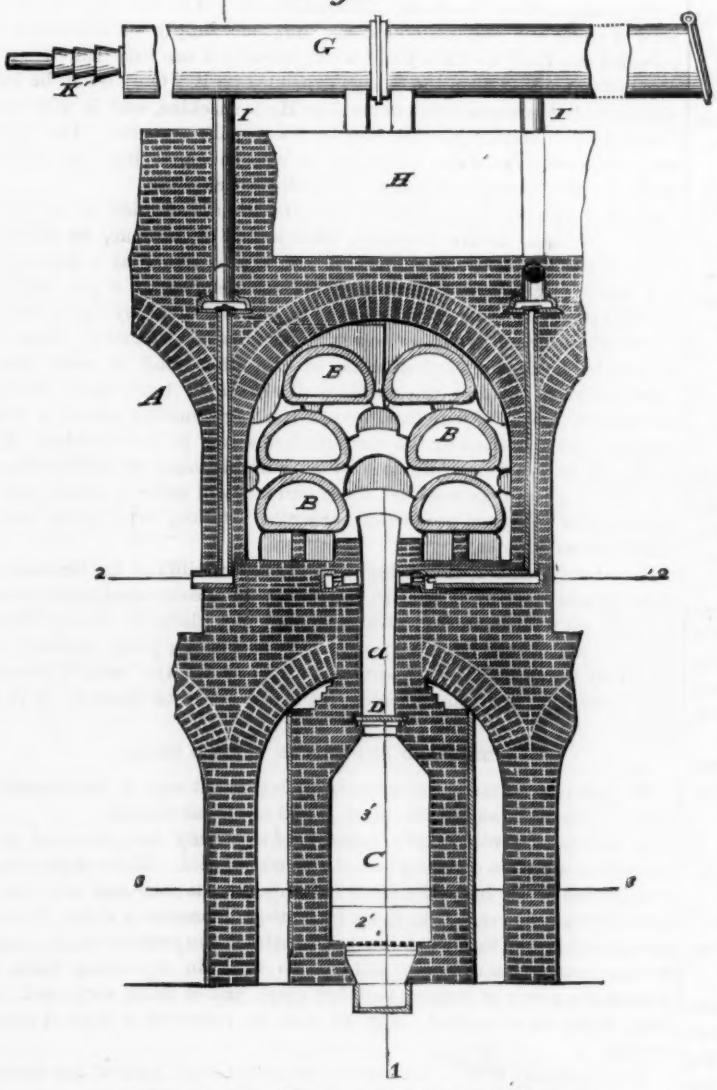
If steady and uniform intensity of heat, and freedom from stopped standpipes, and similar annoyances, is a desideratum for the gas man of the present or the future, it is, in the opinion of your correspondent, excellently solved in the method of procedure pursed by Mr. McIlhenny.

The figures given are the actual results of the twenty-four hours' working of the date of December 19th, 1881. The experimental bench which has been fitted up to give a trial to the working of the new system of recuperative furnace consists of six retorts, the dimensions of which are 15″ × 26′ × 9′, and are of clay. The retorts have been charged once every three hours, with an average charge of 320 pounds of Penn-Youghiogheny coal in the usual manner. On some occasions charges of 330 pounds have been employed, but it was found more expedient to work with the smaller quantity. The charges are most thoroughly and completely burned off in three hours —the resultant coke evidently having been divested of all its hydrocarbons, or, as the foreman rather neatly put it—

"There, Sir, that coke does not owe the gas company anything!"

As a usual thing, upon drawing a charge, it is noticeable that, from the interior of the mouthpiece, to probably a depth of from 10 to 12 inches, a retort bears evidence that the forward end has not been so thoroughly heated as it should have been; in the experimental bench, however, this is not so. The furnace carries the heat to the retorts most evenly—and the front end, even out to the very mouthpiece, is as well and perfectly heated as the middle and back portions.

Fig. 1



Transverse Section through Center of Furnace.

On December 19th these six retorts were charged with a total weight of 15,360 pounds of the before-mentioned coal, and the total amount of gas made was 76,800 cubic feet of 17-candle gas. The fuel used to effect this result was less than twenty-four per cent. of the coke made. The figures here given might have, with strict justice, been much more favorable; but whatever doubt may have at any time arisen during the process of charging or drawing was placed against the credit of the bench.

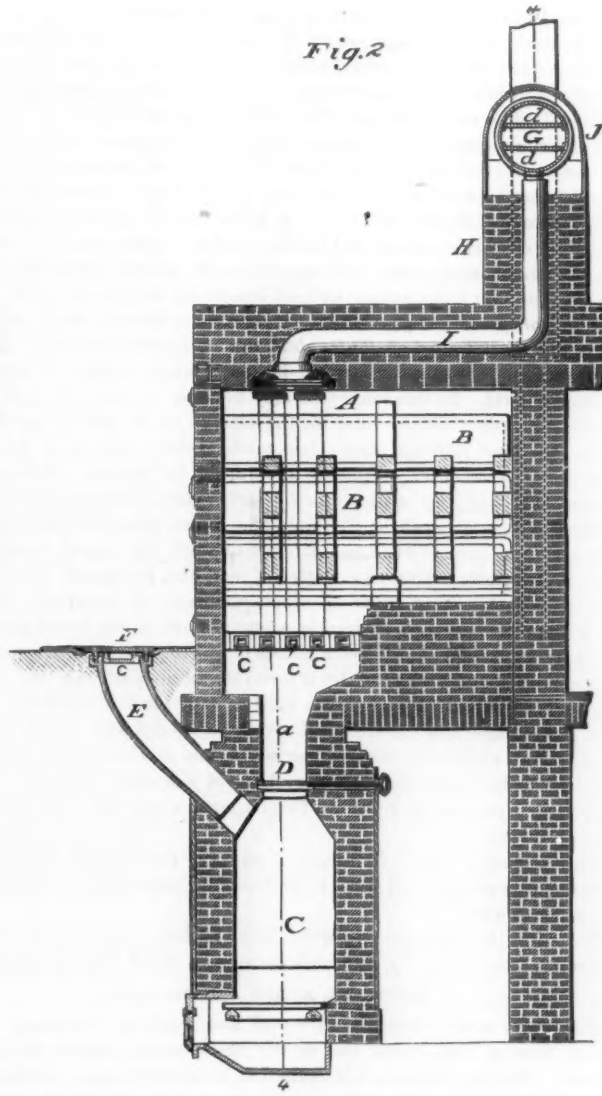
The ease and simplicity of the whole operation (which was witnessed by your correspondent in all its details) and the cleanliness and rapidity with which everything was accomplished, was the more readily discernible when contrasted with the old methods of firing and clinkering.

No precisely exact data of the intensity of the working heat could be at present ascertained; but the estimates of experts place the average at about 3,500°, although your correspondent is inclined to think that this figure was very much exceeded.

In the practical working of this bench, which has been in daily operation for the past two months, it has been proven to the satisfaction of Mr. McIlhenny, and his assistants, that instead of the intensity of the heats having had any injurious effect upon the life of the retorts, the contrary is the case. The gentleman claims that, and with reason too, steady, uniform and reliable heats, even if they are great, cannot but prove a decided advantage over the present system of heats of an uneven grade.

The President and Directors of the Washington Gas Light Company are so well pleased with the experimental results that they have decided to alter their works to this system.

Fig. 2



Longitudinal Section through Center of Furnace.

The Storage of Electricity.

By Sylvanus P. Thompson, B.A., D.Sc., Professor of Experimental Physics in University College, Bristol.

Introductory.

Science has of late made two advances, the ultimate importance of which it would be difficult to overestimate. Not many months before he was seized with the mortal illness which robbed us too soon of his rare and unique genius, Prof. Clerk Maxwell was asked by a distinguished living man of science what was the greatest scientific discovery of the last twenty-five years. His reply was: "That the Gramme machine is reversible." His far-reaching and philosophic mind had perceived that in this phenomenon, which to so many had seemed little more than a curious scientific experiment, lay the principle which, if rightly developed, would render possible the electric transmission of power, and, in the solution of this practical problem, bring about social and economic changes, the importance of which but few of us have even yet begun to realize.

If we could to-night summon up the noble spirit of the philosopher and ask him to tell us what recent scientific discovery came next in importance to this, I think we should receive the reply "that a voltaic battery is reversible." The reversibility in the action of the voltaic cell is the counterpart and complement of the reversibility of the Gramme machine; for while the one has solved for us the problem of the *electric transmission of power*, the other has solved for us the problem of the *electric storage of energy*.

The storage of electricity in such a form that it shall be available for producing electric currents, and for the electric transmission of power, is a fact of so great importance, both in science and in commerce, that no apology is needed for bringing the subject before the Society of Arts. *But the electric storage of energy, which is the end attained, must not be mistaken for the storage of that subtle agent, electricity itself.* A century ago it was thought that the Leyden jar provided a means of bottling up electricity itself. In one sense this may be true, though the fact remains that the more carefully we hunt for the charge of electricity condensed in the jar, the more difficult does it become to realize that there is anything there; and *it is doubly difficult to find, in the electric accumulator or storage cell, anything which can be called stored electricity.* In electric accumulators, such as those of Planté and Faure, electric currents are made to do a certain kind of work, which store of work can again yield us currents of electricity. But, as a matter of fact, the particular kind of work done is, as we shall see, quite as much chemical as electrical. Just as in Sir William Armstrong's hydraulic accumulators, water forced into a vessel with a great pressure furnishes a means of storing mechanical power under such conditions that when we let it down it can do work for us, so in the electric accumulator, by which we want to store electric currents, we use a chemical storage, and the chemical work so stored can itself, as it runs down, set up electric currents in our wires, and do electrical work for us.

Before dealing with the various systems of electric storage that have been suggested, I purpose to lay down two important general principles. They are as follows:

Firstly, that no kind of storage of energy, mechanical or electrical, is possible, except by doing work in overcoming some force which itself opposes the process.

Secondly, that the action in which work is thus done must be one that is reversible; that is to say, to which there is an equal and opposite reaction.

ELECTRICAL ACTION AND REACTION.

"To every action there is an equal and contrary reaction." In these words Newton laid down the great fundamental principle of mechanical science. Its application is not limited to such mechanical reactions as the recoil of a gun, the return of a bent spring, or the mutual attractions of the planets, but reaches down into other departments of science. To Newton himself we owe the simple experiment in which he proved the extension of the principle to magnetic forces. He found the magnet to be drawn toward a piece of iron with a force precisely equal to that with which it drew the iron to itself. It was left to Newton's great contemporary, Robert Boyle, to demonstrate that the same law held good also for the force of electric attractions; an electrified body drawing a non-electrified one toward itself and being itself attracted with an equal and oppositely directed force.

But Newton himself showed that there existed another and deeper meaning to the law of action and reaction, when he laid down the famous comment* which, though forgotten until unearthed by Sir William Thomson, virtually anticipated the nineteenth century discovery of the conservation of energy. As understood in the light of modern dynamics, any "action" in which energy is spent and work done is found to have its corresponding "reaction" in the possibility of the energy thus stored being at some later time set free. That particular "action" of an agent to which Newton told us there was still an equal "reaction," when the action was measured by the product of its momentum into its velocity, was in fact nothing other than its *capacity for doing work.*

If you lift a pound of iron to a certain height against the pull of gravitation, the action implies the expenditure of a certain amount of energy, the equivalent of the work done. Precisely an equal amount of work (saving a trifling proportion converted into unuseful work of another kind—namely, heat) can the mass of iron do in falling back again; for by its fall it may do the work of raising another pound to the same height.

In the science of electricity and in magnetism the same fundamental principal holds good. Suppose, for example, energy to be spent in the following action: Let a heavy weight descend over a pully, and in its descent cause the disc of a Holtz's electric machine to rotate; the work done in this case is electric work, the energy being expended not in moving matter against gravitation or any similar force, but in moving electricity against those electric forces which are continually urging it to run down to the dead level of equal and uniform potential. But our supply of electricity thus provided can itself be made to do work, because it can thus run down and give out in another form the energy expended on it. Only let it be led by wires into the terminal poles of another Holtz machine, and it will drive it round, and by driving it round may be made to lift a weight. The reaction here is the converse of the action, and would be equal but for inevitable waste by friction and dissipation of the electric charges.

Another instance of electric action and reaction is afforded by the reversibility of dynamo-electric machines, such as that of Gramme, as mentioned at the outset. The Gramme machine can be used either as a generator or as a motor. If driven by the power of a steam engine or a gas engine, or by wind power or water power or hand power—in short, by any mechanical means whatever—it generates powerful currents of electricity, which may be used for producing electric lights, or any other kind of work that an electric current can do; the currents of electricity being due to the rapid movements of coils of wire fixed upon a rotating armature across a field of magnetic force, excited by the currents themselves in the machine. If, on the other hand, currents furnished by any suitable source are led by wires into the coils of a Gramme machine, these currents will drive it round, and will expend their energy in producing mechanical rotation, enabling the machine to be used as a motor.

Here I may remark, in passing, that the reversibility of the Gramme machine affords a means of electric, or rather of electro-mechanical storage. Suppose we want to store electric currents. Set them to drive a Gramme machine, and let the Gramme machine, by means of a pully, gradually wind up a very heavy weight. If, subsequently, we let the weight descend, it will drive the Gramme machine, and will generate currents as it runs down.

ACTION AND REACTION IN VOLTAIC CELLS.

We now pass to the more immediately important case of the reversibility of the voltaic cell, and of its chemical and electrical actions.

In the ordinary voltaic cells, currents of electricity are produced at the expense of a certain consumption of zinc and of acid. These materials may be regarded as the fuels of electric currents, just as coke and coal are the fuels of steam power. Like those fuels, they represent a store of energy. Everybody knows that when two bodies attract one another (as for instance the earth attracting a stone), and we do work in separating them, they possess the power of rushing together again, and of doing work; and, therefore, when so separated, may be said to represent a store of potential energy.

This is equally true in the case where we do work against the atomic attractions known as chemical affinity. Zinc has a certain chemical affinity for oxygen. To separate an atom of zinc from one of oxygen requires energy to be expended. When thus separated they have the chance of doing work in reuniting, this work generally appearing in the form of heat. When a piece of coal is burned—that is to say, is permitted to unite chemically with oxygen—its store of energy runs down, and manifests itself in the evolution of heat. A piece of coal represents a store of energy. So does a bag of hydrogen gas; so does a piece of zinc, for zinc can burn directly and give out heat, or may burn indirectly by being dissolved in sulphuric acid, also giving out heat. A Daniell's battery represents a store of energy. A pinch of gunpowder also represents a store of energy. The amounts differ, it is true; and the rate at which some of these stores can be made available for use also differs widely in the different cases.

An ounce of coal represents an amount of energy which, if entirely expended in doing work, would raise 695,000 pounds one foot high against the force of gravity, or would do 695,000 foot-pounds of work. In an ounce of gunpowder is stored about 10,000 foot-pounds of energy. An ounce of zinc represents a store of only 113,000 foot-pounds. An ounce of copper

* ("Treatise on Nat. Phil.," Chap., II., Art. 269):—"Work done on any system of bodies has its equivalent in work done against friction, molecular forces, or gravity, if there be no acceleration; but if there be acceleration, part of the work is expended in overcoming the resistance to acceleration, and the kinetic energy developed is equivalent to the work so spent."

represents a store of about 69,000 foot-pounds only. An ounce of hydrogen gas will yield, by combining with oxygen, 2,925,000 foot-pounds of work. Joule first showed us how to make use of facts like these, in calculating by its mechanical value the electric power of voltaic cells. Let us apply these considerations to the storage of energy in any ordinary voltaic cell—say, for example, the Daniell's cell used in telegraphy. In this cell we have certain liquids containing zinc and copper, chemically dissolved in sulphuric acid, and into these liquids dip a plate of zinc and a plate of copper. The zinc plate slowly dissolves away, and at the same time metallic copper is gradually separated out of the solution, there being about 1 1-20 ounces of zinc consumed for every ounce of copper deposited. Now, to separate an ounce of copper from its solution in sulphuric acid requires 69,000 foot-pounds of energy to be spent upon it; and as 1 1-20 ounces of zinc represents a storage of 118,650 foot-pounds, the consumption of this weight of zinc is enough to provide the 69,000 foot pounds needed to separate the copper, and to leave a surplus of 49,650 foot-pounds. It is *this surplus which goes to maintain electric currents in the circuit, and to do electric work.*

But, as we have remarked, the voltaic cell is reversible. If we take such a cell, and by means of some superior electromotive force drive electric currents back through the cell, the whole action will be reversed. Copper will be dissolved and zinc will be deposited. The copper in dissolving will help the process by giving part of the necessary energy, and our currents will once more give us back pure zinc, and so separating out the zinc we do work and actually store energy.

In modern treatises on heat frequent reference is made to an ideal and wholly impossible sort of engine known as Carnot's reversible engine, which is supposed to have the power of being worked backward, not, however, in the engineer's sense of reversing the motion, but in a much more striking sense. Carnot's engine, like every other engine, is supposed to act by heat passing through it from a boiler to a condenser, part of the heat so passing through being converted into work, and the ideal reversibility consists in the suggestion that if the engine could be driven backward by spending mechanical power upon it, the work should be converted back into heat, and the heat should be pumped back from the condenser into the boiler, and from the boiler back into the fuel.

But while Carnot's reversible heat engine exists in the ideal state, we have in the voltaic battery a real reversible engine; for it is possible here to pump back this electric current into our cell, and even to go further, and to pump into its metallic state the zinc, the fuel which had been consumed in the cell.

POLARIZATION.

Now, while we are thus using currents to separate the zinc from its solution, the zinc is all the while tending to re-unite. Its tendency so to re-unite—its chemical affinity, so called—manifests itself as a counter electromotive force, this counter electromotive force being technically known to electricians under the name of "polarization." The name is not a happy one, but will do if we once understand its meaning. Polarization is the electric reaction at the poles or electrodes of a cell, and is of the nature of a counter electromotive force. To send a current through a cell, we must apply an electromotive force at least as great as that to which the polarization can attain, or we shall not overcome the tendency of the separate elements to reunite. In fact, it is in overcoming this polarization force that we do the work of storage. We do electro-chemical work by overcoming electro-chemical forces, just as we do mechanical work by overcoming mechanical forces. In every case the storage is effected by overcoming some reaction. If weights that have been lifted, and springs that have been bent, and metals that have been chemically separated, all did not tend to return to their former condition, none of these could serve as vehicles or instruments for the storage of energy. Without reaction, storage of energy would be impossible.

It will next be convenient to glance briefly at the principal laws affecting the counter electromotive forces of polarization—that is to say, those electromotive forces which are developed by currents at the polls of the cells, and which tend to oppose a reaction to the currents that evoke them.

LAWS OF POLARIZATION.

To tear away an atom of any element from its compound with an atom of another element, requires the use of a definite amount of electricity, and necessitates, further, that this electricity should be urged forward with at least a certain minimum electromotive force. Take, for example, the case of the decomposition of water by the electric current. To tear away a single gramme of hydrogen from the oxygen with which it is combined requires no less than 95,050 webers ("coulombs") to flow through. But these liberated and separated gases are in one sense a store of energy, and would, if allowed to combine together (by burning), produce heat. Their affinity for one another is very great, and the electric current has to do a considerable amount of work in tearing these two kinds of atoms away from one another. To see what this work amounts to, let us inquire how many units of heat they would evolve in burning. Careful measurements by Favre, Andrews, and Julius Thomsen, show that 34,000 calories of heat would result. Now, the work done to separate the gases is of course equal to the work they would do by rushing together. The affinity of the gases manifests itself as a reaction against the electromotive force of the current employed to separate them. This reaction is itself a counter electromotive force. When we overcome an opposing electromotive force by pushing a certain quantity of electricity from one point to another against its reaction, we do work just as truly as when we overcome an opposing mechanical force by pushing a certain lump of matter from one point to another against its resistance.

In the particular case of the decomposition of water, the opposing electromotive force of polarization has a magnitude when expressed in the proper units of 1.49 volts. It is possible, when we know how much heat would be evolved by the combination of an equivalent of any substance with oxygen, to calculate the amount of the electromotive force that would have to be applied to tear away that substance from its combination with oxygen. Or, again, suppose we know that of two elements one will, when combining with its equivalent of oxygen, give out more heat than another; then we know that it has a greater affinity for oxygen, and, from the difference between their "heats of combination," we can calculate the surplus of electromotive force that we should have to apply to tear away one of these two from oxygen, and to put the other in its place.

In the accompanying table are given, firstly, the equivalent heat values of the various metals when oxidized and dissolved in sulphuric acid. In the second column are given the electromotive forces that would be needful to tear away these elements from oxygen, or with which they tend to unite with oxygen—the value, in fact, of the electromotive force which measures electrically the chemical affinity of each of these elements for oxygen.

The order in which these elements are arranged is, in fact, nothing else than the order of oxidizability of the metals (in the presence of dilute sulphuric acid); for that metal tends most to oxidize which can, by oxidizing, give out the most energy. It also shows the order in which the metals stand in their power to replace one another (in a solution containing sulphuric acid). Thus, if copper be put into a solution of platinum, the platinum is reduced and some of the copper dissolves, evolving heat. If, however, zinc be placed in a liquid containing a copper compound, it displaces the copper, throwing down the latter as a metal and itself dissolving, while its surplus stored energy runs down as heat. In this order, too, the lowest on the list first, are the metals deposited by an electric current from solutions containing two or more of them; for that metal comes down first which requires the least expenditure of energy to separate it from the elements with which it was combined.

[The calculation of the figures in the second column (the electromotive forces) from those of the first column (the number of the calories of heat evolved by the oxidation and solution of that amount of the substance that is chemically equivalent to one gramme of hydrogen) is effected in a manner originally suggested by Mr. Joule and Sir William Thomson. The number of heat units or calories is ascertained by direct experiment in the calorimeter in the manner familiar in the researches made on heat of combination by Favre, Andrews, Julius Thomsen, and Berthelot. Now, Faraday showed that the qualities of metals concerned in the electro-chemical operations in voltaic and electrolytic cells are proportional to their chemical equivalents; and the later researches of Weber, Kohlrausch, Mascart, and Alder Wright have shown that this proportionality can be expressed by a numerical coefficient, which we may call the "Faraday coefficient," and which will depend on the unit in which electrical qualities are expressed. If we take the coulomb (or "weber") as the unit of electric quantity, then the Faraday coefficient is 0.000105; or, in other words, each weber (or coulomb) of electricity which passes through a cell will involve the liberation or combination of 0.000105 grammes of that element, whose chemical equivalent is 1, and proportionally more of those whose chemical equivalents are greater. The heat value of the chemical work done by one weber (or coulomb) of electricity, in removing or depositing any metal in any cell, is obtained by multiplying by 0.000105 the figure standing opposite the metal in question, in the first column of the table. These heat values are turned into absolute units of work by multiplying by Joule's mechanical equivalent of heat, which is, in the centimeter-gramme-second system of units, equal to 41,530,000, or 41.53×10^6. But the work done in moving a unit of electricity against the reaction in a cell measures the power of that cell to react electrically; or, in other words, measures the electromotive force relatively to oxygen, which is taken here as the standard electro-negative substance. These electromotive forces will be expressed in terms of the appropriate of electromotive force, the volt.]

REACTION OF PEROXIDES.

In the preceding discussion, oxygen has been taken as the standard electro-negative substance. But in point of fact there are substances more highly electro-negative; that is to say, substances which when made to com

TABLE OF ELECTROMOTIVE FORCE AS CALCULATED FROM THE HEAT OF OXIDATION OF THE CHEMICAL EQUIVALENT (H = ONE GRAMME) AND AS OBSERVED BY DIRECT EXPERIMENT.

Name of Substance.	Heat Value.	E. M. F.	Electromotive Force observed in Dilute Sulphuric Acid.				
	Calories.	Volts.	With Oxygen.	With Platinum.	With Ozone.	With Peroxide of Lead.	With Zinc.
Potassium	69,800	3.04		3.17 (Bf.) 2.484 (Wh.)		3.528 (Wh.)	—1.144 (Wh.)
Sodium	67,800	2.95					
Zinc	42,700	1.862	1.873	1.546 (Po.) 1.439 (Wh.) 1.67 (Bz.) 0.637 (R.)		2.448 (Wh.) 2.98 (J.)	0
Iron	34,120	1.570					[0.600 (A. & P.)]
Hydrogen	34,100	1.493	? 1.64 (Ta.)	0.86 (R.) 0.877 (Bz.)	1.9 (R.) 2.1 (Wh Po. Sv.) 2.3 (Bf. Ta.) 2.265 (Ba. Bz.)	? 2.78 (Pl.)	
Lead	25,100	1.133				2.38 (Pl.)	0.21 (A. & P.) 0.55 (D. L. R.)
Copper	18,760	0.818	0.74 (R)	0.550 (R.)			0.953 (Po.) 1.079 (L. C.) .978 (L. C.) [0.75 (A. & P.)]
Silver	? 9,000						
Platinum	7.500	0.327		0	1.21 (R.) 1.04 (R.)	0.6 (R.) 0.75 (R.) 0.90 (Wh.)	1.546 (Po.) 1.439 (Wh.) 1.67 (Bz.) [0.981 (A. & P.)]
Carbon	? 2,000				1.435 (L. Swj.) 1.18 (R.)		[1.096 (A. & P.)]
Oxygen	0	0	0				
Nitric Peroxide	—6,000	—0.29					1.97 (Bf.) 1.95 (L. C.) 1.96 (Sb.)
Chromic Peroxide	—7,195	—0.31					2.028 (Sb.)
Maganese Peroxide				—0.54 (Wh.) —0.101 (R.) —0.128 (R.) —0.404		0.504 (Wh.) 0.426 (J.)	1.944 (Wh.) 2.55 (J.)
Lead Peroxide				—0.6 (R.) —0.75 (R.) —0.90 (Wh.)		0	2.448 (Wh.) 2.98 (J.) 2.1 (D'A.)
Silver Peroxide				—0.7 (R.) —0.86 (R.)			
Hydrogen Peroxide	10,800						
Ozone	14,800	—0.645		—1.04 (R.) —1.21 (R.)	0		

D'A., D'Arsonval; Ba., Bartoli; Bf., Buff; Bz., Beetz; L. C., Latimer Clark; D. L. R., De la Rue; J., Joule; L., Lenz; Pl., Plante; Po., Poggendorff; R., Raoult; Sb., Sabine; Sv., Svanberg; Swj, Saweljew; Ta., Tait; Wh., Wheatstone; A. & P., Ayrton and Perry (whose observations, being made with an electrometer for contact in air, are placed in square brackets, as not being, like the rest, observations on the electromotive force in sulphuric acid.

bine with a metal such as zinc would give out together a larger amount of heat than zinc does with oxygen. Chief among those substances are chlorine and the haloids, the peroxides of the metals manganese, lead and silver, such peroxidized bodies as chromic, perchloric, and permanganic acids, the peroxide of hydrogen, and ozone. If, for example, zinc be caused to combine with an equivalent of peroxide of lead, more heat is evolved than by the mere oxidation of zinc by free oxygen gas. It is clear then that in the unstable chemical aggregation of the peroxide we have a store of energy which can be utilized in giving us voltaic cells of still higher electromotive force. The highly electro-negative (or oxidizing) property of the brown peroxide of lead was discovered in 1835 by Munck of Rosenschold, who describes it as being the most highly electro-negative substance known, being superior even to the peroxide of manganese which Volta found so highly electro-negative. There are, as a matter of fact, several oxides of lead, containing least oxygen of all these oxides; *minimum* or red lead, containing a greater proportion; and the *brown* peroxide, with the highest proportion of oxygen, the best conductor and the most highly electro-negative of them. The peroxide of silver is still more highly electro-negative. This power can easily be verified by making a small voltaic cell with a pair of plates, the one platinum covered with a film of peroxide of lead, the other of zinc. One such cell will decompose water, which a copper-zinc pair will fail to do. For to do this requires, as may be seen by the table, an electromotive force exceeding 1·493 volts, this being the measure of the affinity of hydrogen for oxygen. The platinum-zinc pair would have an electromotive force of only 1·044 volts, while that of a peroxide of lead-zinc pair is about 2½ volts.

MINIMUM ELECTROMOTIVE FORCE FOR CHARGING.

The electromotive force of polarization in a cell, evoked there by the passage of a primary current through it, will depend upon what circumstances are produced at the two electrodes by the passage of the current. In the case of all ordinary liquids and metallic solutions, the products are known.

For each electrolyte there is a minimum electromotive force, without which, complete decomposition cannot occur. For water, for example, this minimum is 1·495 volts. If the current be of less electromotive force than this minimum, the action may begin, but the charging current will be stopped the moment the opposing electromotive force of polarization has risen to an equal amount. It is for this reason that in charging a Planté cell, or a Faure cell, we must use at least two cells of Grove's or of Bunsen's battery, or at least three cells of Daniell's battery.

The chemical work that is done in any secondary battery, or electrolytic cell, is proportional to the strength of the charging currents, to the time it lasts, and to the effective minimum electromotive force of polarization in the cell itself. It is not increased by increasing the electromotive force of the charging current much beyond this value; for though a higher counter-electromotive force may be temporarily called out, the work done against this added opposition is wasted in local heat, which is detrimental to the power of the cell. The cells should be charged with only just sufficient electromotive force to overcome their reaction. To charge a Planté cell, two Bunsen cells—not twenty—should be used. The storage will be slower, it is true, but it will be more economical, by far.

STORAGE POWER LESSENED BY HEAT.

Heat diminishes the counter-electromotive force of the cells during charging; it therefore diminishes the amount of chemical work done in charging them, and diminishes the amount of charge thereby stored. Secondary batteries should be kept as cool as possible during charging. A simple experiment in proof of the diminution of polarization by rise of temperature is the following. Let a single Grove's cell be connected with a water-voltameter; no gases are evolved until the voltameter is heated to near boiling, when the gases come off freely. Bartoli examined the electromotive force of polarization in a cell containing sulphuric acid with electrodes of plati-

num, and found it to be twice as great when the liquid was at 5° C as when raised to its boiling-point. Beetz and Robinson have independently investigated the same effect, and their results agree precisely. Beetz found the polarization 2·216 volts at the ordinary temperature of 20° C, and as the temperature was raised it fell off, gently at first, more rapidly afterward, till at 100° C it was only 1·904 volts.

Temperature.	E. M. F. (Beetz).	E. M. F. (Robinson).
16° C	2.216	....
20°	....	2.216
30°	....	2.194
43°	....	2.148
53°	....	2.105
57.5	2,101	....
60°	....	2.095
80°	....	2.040
94°	1.960	....
100°	....	1.904

IMPORTANCE OF SUFFICIENT CURRENT DENSITY.

The influence on the polarization-force of a cell of the size of the plates used as electrodes relatively to the strength of the charging current has also been investigated by several experimentors, amongst them Crova, Poggendorff, and Bunsen, and more recently by Bartoli and Blondlot. It is found that the degree to which a counter-electromotive force of polarization force is set up depends very greatly on the quantity of current per unit of surface of the electrodes employed. If the current be weak, and the electrodes large, the polarization never reaches its maximum. On the other hand, if the electrodes be of very small surface, and the current a strong one, the polarization may attain abnormally high values. Thus Buff, electrolyzing water with small platinum points, found the counter-electromotive force to be no less than 3.57 volts. This difference between this and the minimum value of about 1.493, must be accounted for by the fact that the state of the liberated products varies with the condition of liberation. With greater "current density"* the gases liberated by decomposing water are no longer simple oxygen and simple hydrogen. With greater current-density, a greater proportion of the oxygen comes off in the more highly electro-negative condition of ozone, and more peroxide of hydrogen forms also round the anode, whilst at the kathode, the hydrogen which is evolved possesses in unusual degree the active properties attributed by chemists to "nascent" hydrogen; that is to say, a larger proportion of it probably is, at the moment of liberation, in some abnormal allotropic condition, bearing the same kind of relation to ordinary hydrogen as ozone bears to oxygen. The allotropic hydrogen is more oxidizable; the ozone more ready to oxidize. Their union would evolve more heat than the union of equal weights of ordinary hydrogen, and ordinary oxygen. It requires greater electromotive force to keep them apart; their own tendency to unite is greater. J. Thomsen has even measured the heat value of ozone as compared with oxygen, and it takes its place in our table of elements at the bottom below the peroxides, though chlorine and the haloids would be still lower on the list if they came within the scope of present considerations.

It follows from the above argument, that if we wish to make our storing cells exert their highest possible reaction, we must store them, using a current whose strength (or quantity) is proportioned to the size of the cell. If we use too weak a current, the maximum polarization, and therefore the maximum efficiency, will never be attained. This is one of the rocks on which amateur constructors of storage batteries have come to grief. The current-density† is a most important consideration, especially in the early stages of the formation of the cells. It certainly should not be less than 50 milliwebers per square centimetre of surface in the cell.

EFFECT OF STATE OF SURFACE.

Again, the state of the surface of the electrodes has much to do in determining the state in which the gases are liberated, and the resulting polarization force. Svanberg, in electrolyzing water with copper electrodes, found the polarization to be .72 volts with smooth plates, and only .47 with corrugated plates. Poggendorff, using platinum plates, found the maximum polarization to be—with bright surface, from 2.28 to 2.50 volts; while with surfaces platinized, *i.e.*, coated with a black, powdery deposit of platinum, the polarization in cells, like those of Planté and Faure, where the original surfaces of the plates of lead are coated with thick films of peroxide, or of reduced metal, these considerations do not apply, except for the first operation of charging. Indeed, I have found, experimentally, that there is a gain in scratching the leaden surfaces, before forming the coating of peroxide; the coating is more adherent, and the effective surface somewhat greater; advantages beside which the greater preliminary waste of liberated gases on first charging is comparatively trivial.

We will next take a brief historical glance at the various stages in the invention and perfection of accumulators or storage batteries.

HISTORICAL SUMMARY.

Within one year after the discovery of the pile by Volta, two very important observations had been made. Nicholson and Carlisle, in 1800, discovered that the current so produced could decompose water;* and in 1801 Gautherot discovered that the wires of platinum or of silver which had been employed to thus decompose salt water acquired, and retained after being detached from the pile, the power of yielding a transient current, as could be proved by their efficacy in causing muscular contractions in a frog's leg, and in yielding the so called galvanic taste. This is the phenomenon afterward denominated "the polarization of the electrodes." It was found to consist in a peculiar state of the electrodes which manifested its presence, even before the exciting current of the pile was cut off, by producing an enfeebling reaction against that current, the polarization current being in a direction which opposed the exciting current. The phenomenon is well known to all electricians, and occurs not only in electrolytic cells, but in the cells of the voltaic batteries, where the liberation of hydrogen bubbles is accompanied by an opposing reaction of the same kind. Indeed, the difficulty with batteries has been to get rid of the polarization.

In 1803, Ritter, of Jena, re-observed the same phenomenon, using wires of gold; and perceiving the importance of this reaction, he constructed a secondary pile which we will presently describe.

The phenomena of the secondary currents due to polarization were further investigated by Volta, Marianini, Davy, Grotthuss, De la Rive, Sinsteden, Bacquerel, Schœnbein, Matteucci, Grove, Faraday, Buff, Beetz, and others. Matteucci and Grove in particular studied the reaction-currents set up by the presence of uncombined gases at the electrodes, and the latter constructed a well-known "gas battery." In 1869, M. Gaston Planté brought out a secondary battery constructed of lead plates dipping into sulphuric acid, and in a remarkable and valuable series of classical researches, he investigated the phenomena of their action. More recently, modifications of the Planté accumulator have been suggested by M. Camille Faure and M. A. de Méritens. These various systems will be described in detail presently. Professors E. J. Houston and Elihu Thomson, of Philadelphia, have made the suggestion which embodies the principle of reversibility in the case of the Daniell's cell. They place two horizontal copper plates in a cell containing sulphate of zinc in strong solution. To change this cell, a current is sent through it from the top plate downward. The upper plate or anode dissolves, forming a solution of sulphate of copper, which, being specifically lighter, floats on the sulphate of zinc. On the lower plate, metallic zinc is deposited; so that, when charged, this battery is merely a "gravitation Daniell" battery. It will afterward yield a current so long as there remains any zinc in the metallic state, or so long as there exists a chemical difference between the two electrodes. This suggestion has been modified by M. d'Arsonval, who uses an electrode of lead, or of carbon covered with leaden shot along with an electrode of zinc in sulphate of zinc. In this case, when the cell is charged, zinc is deposited upon the zinc plate, while the lead becomes peroxidized.

RITTER'S SECONDARY PILE.

Ritter discovered the possibility of secondary voltaic action while studying the chemical action of electric currents upon liquids. He employed a large voltaic pile as his source of electricity, and observed, not only the decomposition of water into oxygen and hydrogen, but the phenomena of formation of peroxides, and of the deposition of metallic films at the anode and kathode respectively, when metallic solutions were employed. He found that his gold wires, after becoming covered respectively with film, if separated, oxygen and hydrogen could set up violent contractions in a frog's leg. He further investigated the phenomenon with different kinds of wires, and found platinum to yield the best result, gold coming next in order, then silver, copper, and bismuth. With lead, zinc, and tin, however, he obtained no result. He further showed that even after having been removed from the water and dried, the pair of gold wires retained their activity, and when

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* This term means "the amount of current per unit of surface of the electrodes," and is calculated for either electrode (in the simple case of parallel plates), by dividing the total strength of the current in webers (*emperes*) by the area of that electrode in square centimetres.

† Crova, and more recently Bartoli, have given exact formulæ, by which to express this important relation. Let P represent the E.M.F. of polarization at any time; it can be expressed as a function of the possible maximum polarization and of the density of the current. Let A be this possible maximum E.M.F; s= the surface (supposed uniform), q the time t (supposed short), then

$$P = A\left(1 - 10^{-\frac{q}{as}}\right)$$

where a is a constant (8,400 circ.) This may be interpreted as follows: The polarization falls short of its possible maximum by an amount the logarithm of which is inversely proportional to the current density.

* Water had previously been decomposed by discharges from an electric machine in 1789, by Paetz von Troostwyk and John Cuthbertson.

afterward plunged into water yielded a current in a direction opposed to that of the pile, by which they were originally rendered active.

One remarkable experiment of Ritter's found its way into English journals. Ritter took a *louis d'or*, and placing moistened cloth against its two sides, proceeded to pass through this combination a current from a powerful pile. The coin still laid in its wrappings was afterward found capable of furnishing a current. This led Ritter to propound the view that conductors of electricity, such as metals, could be charged with electricity; the coin between its metal wrappings being, according to him, the analogon of the Leyden jar lying between its two coatings of tinfoil. He mentions also mercury, carbon, graphite, and binoxide of manganese, as being capable of receiving galvanic charges. "Each of these bodies," he says, "becomes charged upon both its sides just like the glass of the Leyden jar, and this state of charge, when it exists in such concentration or intensity, as in the foregoing bodies, is perceived as a state of oxygenation on one side, and a state of hydrogenization on the other." He also draws attention to the curious behavior of quicksilver, which, when placed between water and water, and included in the circuit of a voltaic pile, shows movements due to changes in surface-tension where the films of gas are produced. Ritter advanced to the rather unwarranted conclusion that, since in these cases the charge stored up depended on the pressure of oxygen and hydrogen films produced from the water, there must necessarily be water in all bodies, and that chemical separation always accompanied electric charge.

To produce these effects of galvanic charge upon a larger scale, Ritter constructed a secondary pile (*Ladungs-Saule*), consisting of a series of discs, of one metal—copper—separated by pads of cloth, moistened with a solution of salt, or sal ammoniac. When charged from a voltaic pile of ordinary construction, this secondary pile received a charge, which afterward enabled it to give a shock to a person touching its two ends with his hands. It would also decompose water, and, in short, reproduce all the effects of the primary pile, but reversed as to the direction of the currents it furnished.

Ritter was not happy, however, in all his efforts to explain what he observed. He founded his arguments on the incorrect supposition that oxygen consisted of water, combined with negative electricity. It was some years before the researches of Volta, Marianini, and Schonbein, placed the phenomena on their true basis; Schonbein adding the very valuable observation that the presence of ozone in the liberated oxygen intensified the secondary electric action.

PROGRESS IN ELECTRO-CHEMICAL KNOWLEDGE.

The researches of Davy, De la Rive, and of Faraday, upon the chemical phenomena of the voltaic cell, showed that the chemical decompositions within the battery were amenable to the same laws as those which took place in an electrolytic cell at a distant point of the circuit. Faraday brought out several most valuable points in his "Experimental Researches." He describes (Art. 750) how, in electrolyzing acetate of lead, "in place of oxygen, or even the gases already described, peroxide of lead now appears at the positive,* and lead itself at the negative pole." In his argument for the chemical theory of the cell, he remarks that while those substances are highly electro-negative which cannot be oxydized, there is another class of substances still more highly electro-negative, namely, those substances which readily give up oxygen, the peroxide of manganese being more negative than platinum, as Volta showed, and the peroxide of lead being still more negative than that of manganese, as Munch af Rosenchöld had shown. Faraday remarked (Art. 1822) on the good conducting power of the peroxide of lead. He also observed that red lead is more negative than platinum. De la Rive indeed utilized the strong electro-negative property of peroxide of lead in the construction of a cell in which this substance, packed in a porous pot around a platinum slip, served as one pole, zinc being the other. Niaudet, in his treatise on the "Pile Electrique" (published 1878), suggests that red lead (minimum) would have answered equally well. In the Bakerian lecture for 1843, Wheatstone announced that he had measured the electromotive force of peroxide of lead against zinc, and had found it to be 2.266 of that of a Daniell's cell (= 2.448 volts.)

GROVE'S GAS BATTERY.

In 1842, Sir William (then Professor) Grove described the well known gas battery, which was indeed nothing else than a reversible oxygen and hydrogen battery, in which work had first to be done to produce chemical decomposition, electric currents being passed through acidulated water from one platinum pole to another, these currents being of sufficient power to overcome the opposing mutual affinity of the constituent gases, the reaction of these separated gases tending to produce a counter-current of considerable power, and manifesting a so-called electromotive-force of polarization.

The rationale of the gas battery is simple enough, provided it be once understood that platinum possesses a power almost unique amongst the metals, of absorbing upon its surface both oxygen and hydrogen gas. When a current is passed between platinum electrodes in acidulated water, the two gases not only rise in bubbles, but form a film at or in the surface of the metal, which when so charged behaves differently from neutral clean platinum. The hydrogenized film resembles zinc or some oxidizable metal, and exercises toward clear platinum, and *a fortiori* toward oxygenized platinum, a strong electromotive force. The energy spent by the decomposing current in separating these gases, is stored in the gases that are thus separated. In their subsequent reunion, the energy of their separation runs down into some other form; into heat if the gases are merely mixed and exploded together; into the energy of electric currents if the gases are suffered to recombine through the liquid, by the slower and cooler process of slow chemical combination in the cell.

With a gas battery of 50 pairs, Grove produced electric lights, effected various chemical decompositions, and produced shocks which could be felt by five persons joining hands.

[To be continued.]

* Professor Adams, commenting on this observation of Faraday's, shows that Faraday thus anticipated Plante in the discovery of the leaden cell. But a Plante cell filled with acetate of lead is almost useless. The fact that peroxides are thus deposited on the anode was thus discovered before Faraday's researches by Nobili, who noticed also the beautiful irridescent colors in the rings of peroxide films deposited on an anode plate opposite a printed kathrode; the phenomenon known usually as *Nobili's* rings.

[From the London "Journal of Gas Lighting."]

The Report of the Board of Trade Committee on Photometric Standards.

SIR.—In your leading article in the *Journal* of the 15th inst., on "The Board of Trade and Photometrical Standards," occurs a sentence which leads me to fear there is an ambiguity of expression in the last paragraph of section 3 of the report of the Committee on Photometric Standards, which deals with Mr. Methven's lamp. The last paragraph of section 3 runs: "But where there is no liability to a greater alteration in the quality of the coal gas than about two candles, the ease and rapidity of Mr. Methven's system may render it extremely useful for determining the illuminating power of gas."

Taken by itself, this passage might mean one of two things. It might mean either that Mr. Methven's lamp gave approximately correct results with coal gas varying in quality over a maximum range of two candles; below the mean—*i.e.*, over a maximum range of four candles. In your leader you appear to attach to it the latter meaning when you say: "The committee have reported that the Methven standard, as applied to the valuation of 16-candle gas, is correct to a degree far within the range of error of the best parcel of sperm candles, throughout a range of two candles above or below the normal quality." But, as is pointed out in the preceding paragraphs of section 3 of the report, the Methven lamp was found to give approximately correct results only when it was used with "coal gas ranging in quality from a little under 16 candles to a little over 18 candles." Therefore, the former of the two meanings given above was that intended by the Committee.

I shall be glad if you will minimize the possible evil effects of this ambiguity by publishing a correction in your next issue.

Balliol College, Oxford, Nov. 19, 1881. HAROLD B. DIXON.

SIR:—I perceive from the letter of Mr. Harold B. Dixon, in your last issue, that he draws attention to the fact that the Committee on Photometric Standards allege that my lamp is only capable of giving approximately accurate results when used with coal gas ranging in quality from a little under 16 candles to a little over 18 candles.

Numerous and laborious experiments, extending over a long period, have convinced me that the range of power of my lamp is considerably greater than that stated by the Committee.

Immediately on seeing the report alluded to, I wrote the letter to the President of the Board of Trade, a copy of which appeared in your issue of the 15th inst. In the letter I stated my conviction that I should be able to remove the objectionable features in my system reported upon by the Committee, while retaining the extreme simplicity approved of by them.

I now have the pleasure of informing you that by a trifling and inexpensive addition to my lamp I have increased its range and that to an extent which will render it efficient under any of the conditions which a gas tester is ever likely to meet. As an instance, I may say that I have lately with my apparatus succeeded in determining the illuminating power of a gas by using gases varying in quality from 9 to 25 candles. The experiments have been frequently repeated, and observations made by two or more operators; the mean of ten observations taken in each case being within 0.2 of a candle.

I am sanguine of obtaining equally accurate results with gases of even a wider range of quality.

Mr. Dixon considers that there is an ambiguity of expression in the last paragraph of section 3 of the report of the Committee; and he concludes his letter by asking "if you will minimize the possible evil effects of this ambiguity by publishing corrections in your next issue." From what I have stated with regard to the increased range of efficiency of my lamp, I hope it will be seen that even if the "evil effects" of the "ambiguity" were not "minimized" no very serious results need be feared.

Nine Elms, S. W., Nov. 25, 1881. JOHN METHVEN.

Gaseous Fuel for General Consumption.

The idea is gradually forcing itself upon the minds of thinking men that the use of solid fuel in small fires, for domestic purposes, under boilers, and in fact almost any situation where heat is needed, is exceedingly wasteful. Anyone with even moderate powers of observation, who will examine any ash heap or ash bin, or who will undertake the care of a coal fire for 48 hours, will soon come to the conclusion that the usual forms of grates, and heaters are not such as to promise any considerable amount of economy even in the most careful hands; while, if employed in the usual manner, it is difficult for the most careless observer not to notice the great waste.

Gas fuel, on the other hand, may be consumed with the greatest economy even on a small scale, and the numerous processes by which a cheap gas can be made justify the consideration of a question which might seem at first glance impracticable. In England the project has recently been agitated of making two kinds of coal gas by the same works and from the same retorts. These different kinds of gases it is proposed to distribute by two different systems of street mains. One of these gases is of poor illuminating quality, and is formed at the beginning and end of the process. The other, which is of high illuminating power, is made during the middle portion of the process. In England little more than 10,000 cubic feet is obtained from a ton of coal, the smallness of the yield being due to the fact that the companies obtain as much or more revenue from the waste products as they do from the sale of gas. In fact, it has been sometimes said that they were really chemical works selling gas as a by-product.

With the arrangement we have just named, which was proposed by Dr. Siemens, it was expected that about 3,520 feet of illuminating gas could be obtained from a ton of coal, and 7,040 feet of heating gas low in illuminating power. It is supposed that this heating gas could be delivered for 1s. per 1,000 cubic feet. We should imagine that this figure could be greatly reduced, for in England the actual cost of the gas to the companies is practically nothing, the real expense account being interest and repairs upon the distributing system.

The system, however, is not likely to be a very profitable one when compared with the systems of heating-gas making which are well established. The so-called water gas processes are capable of giving gases of the very best quality for heating, at a cost to the consumer of 20 to 25 cents per 1,000 cubic feet, covering all the cost of making the gas, interest on distributing system, and cost of working. The gas thus obtained is carbonic oxide. It is said that this gas can be obtained at the rate of 180,000 cubic feet per ton of coal. Its value for heating is not quite equal to that of the finest illuminating gas, but it has the advantage of burning perfectly, without waste or clinkers, and can be lighted in an instant. These are advantages which would place its value far ahead of coal, even though we had to pay for it at the rate of $2 per thousand. With the price of gas in New York, the amount of heat that can be got for 1 cent would be 16,000 heat units for coal and 2,500 for gas. Of the 16,000 heat units which we may theoretically, in ordinary practice, utilize, it is safe to say one-half are wasted; and when gas is reduced in price one-half, the figures will stand 8 to 5. Under these conditions coal and coal-burning stoves would have no chance whatever. It may, of course, be urged in answer that the price of gas cannot be reduced to the extent named. When it is considered that illuminating gas is made for 45 cents per thousand, and that the retail price above that figure represents the interest, wear and tear, cost of collecting, and the profit, it will be seen that any system which will give a large continuous consumption for a low price, will at once furnish every inducement to capital to enter the business.

The consequences which would follow the reduction of ordinary illuminating gas to even $1.75 per thousand are worth careful consideration. No one, when gas could be obtained for such a figure, could well afford to use coal for cooking purposes, save perhaps in the coldest weather. In most rooms a gas stove would do the heating not only as cheaply, but also with much more satisfaction than coal stoves. In a building full of large offices it would avoid the cost and expense of steam heating, and replace it with gas stoves in every room. A gas engine would be used for driving the elevator, and a caloric or gas engine would do the pumping. Of course the cost of heat and power for one year would exceed the cost of the engine and coal, but into the steam heating account would come the insurance upon the boiler, the greater risk upon the building, the interest and depreciation of the whole steam apparatus, the cost of the repairs, which are continuous, and the general annoyance of the steam heating or hot water systems. In the spring and fall of the year the saving over steam would be very material. Each man would regulate the temperature of his room by lighting his heater for a few minutes, and it would not be necessary to keep steam upon the whole system to accommodate a small number of tenants for a few hours in the day, and tenants would not be annoyed by an excess of heat from steam mains.

In the dwelling house the dusty furnace would be laid away and heaters put up in every room where flues could be reached, and even in hall bedrooms it would be possible to take off the "chill" of the room by a gas stove. When a dwelling house is heated by steam the advantages of gas would be fully as marked as when gas replaced coal fires.

A consideration of all the facts leads us to the conclusion that the fuel of the future, for both domestic and manufacturing purposes, will be gas. Its wide introduction among iron working establishments, the economy which it effects, and the superior results which are attained, have made its introduction almost like a revolution.

In spite of the almost fabulous prices for which gas is sold in many cities, gas stoves are steadily gaining ground. The nuisance of ashes, dust, and kindling wood, and the difficulty of regulating the coal fire, are among the reasons which are offered. The gas engineers are straining every effort to produce perfect gas stoves, and with considerable success. It is likely to be a good while before the stove trade feels the competition of gas, but the fact that competition is among the probabilities of the future gives the subject interest. Another generation will probably wonder at our wastefulness in burning solid fuel costing so much to mine and transport, when so much greater convenience and economy attends its conversion into gaseous fuel.—*Iron Age.*

The Future of Gas Lighting.

These is no longer room to doubt that electricity will play an important part in providing the world with light. That it will wholly supersede gas is, however, unlikely; and even if it did take the place of coal gas as a lighting agent, gas would still be extensively employed for heating purposes. Up to the present, the introduction of the electric light seems to have rather operated to increase the consumption of gas than diminish it. Gas engines are employed to a considerable extent in driving dynamo machines; and even where the electric light is used regularly, we find it still supplemented by gas lamps. But it is not to be denied that the introduction of the electric light has done a great deal to improve gas. It supplied a stimulus that was much wanted, and a marked improvement in the lighting of many of our thoroughfares has been the result. A comparison, for example, of Parliament street, Westminster, with the Strand, or any neighboring street, will show of what gas is capable when properly used.

Can it be said that finality has been reached in the production, transmission, and consumption of gas? We think not; and it may yet be found that as the rivalry of the electric light becomes sharper and sharper, so will improvement after improvement take place in the production and use of gas. The direction which improvement may take can be indicated without much trouble. The object of the inventor must be to produce gas more cheaply than is now possible, and to make it better than it is now. The simplest way to secure the first end would be to obtain more gas than ever from a ton of coal. But there is nothing to be done in this direction. The maximum yield has been secured for many years in our best gas works. Thus, at Beckton, the average yield of Newcastle coal with 7 per cent. of cannel is 10,334 feet per ton. It is very unlikely that this result can be exceeded; it is not often equalled. Again, the use of machinery for drawing and charging retorts; the favorable contracts made for coal, the success which has followed judicious efforts to prevent waste, and, in one word, the perfection of the whole system of gas making, seems to have done all that can be done to directly reduce the cost of production. The South Metropolitan Gas Company supply gas as 2s. 10d. per 1,000 cubic feet—a wonderful fact, bearing all the conditions of locality in mind.

As the quantity of gas per ton cannot be directly augmented, and as the cost of labor and general expenses does not seem to admit of diminution, it would appear impossible to do more with gas than has been done; and it might be taken for granted that gas will have to fight electricity just as it is, and has no reserves to draw upon. Such a conclusion would, however, be erroneous. Invention never reaches its limit, perhaps, in any department of the arts and sciences. It certainly has not reached it in gas making. We shall not here go into any elaborate investigation of what is and what is not possible in the manufacture, but we can indicate three directions in which progress seems to be possible.

It has recently been announced that by passing the electric spark through coal gas, its volume may be doubled and also its illuminating power. This is a startling statement, and further experiment conducted on a large scale is required before it will be safe to pronounce an opinion as to the value of the suggestion. There is, however, a basis of truth for what has been said. When sparks from an induction coil are passed through coal gas, acetelyne —C_2H_2—is produced. The volume of the gas is augmented, and perhaps its lighting power. This is, however, only a general statement, and little or nothing outside the laboratory is known on this point. What is known is encouraging.

There are, however, difficulties in the way of adopting the process, however successful it may be. The first is that when acetelyne is produced there is a strong tendency to throw down carbon developed in the gas. The carbon assumes the condition of a black tarry deposit, or, in some cases, benzine—C_6H_6—is produced. There are serious objections to the adoption of any process which entails the deposit of carbon from coal gas. Further, acetelyne attacks copper, and produces acetelyde of that metal, which is probably explosive, like one of the compounds of ammonia with the same metal. There is always present in coal gas about .06 per cent. of acetelyne, and this is said to attack copper pipes with the effect we have named. It is by no means clear how and why the presence of acetelyne should improve coal gas. It contains less carbon than any other hydro-carbon known. The augmentation of volume may be due to the setting free of hydrogen previously combined with carbon. Next to nothing has been done as yet to ascertain on a practical scale of what the scheme is capable. But enough is known to render it desirable that further experiments should be made. It would be very easy to ascertain at any of our gas works the effect of passing a current of sparks from a dynamo-machine through a few thousand feet of coal gas. Should the result be satisfactory, much advantage may be anticipated. Even though the volume and lighting power of the gas should not be doubled, yet if either or both be materially augmented, the result could hardly fail to be contenting, because the cost of carrying out the process would be small.

As to the danger of producing acetelyde of copper, little perhaps need be feared. There is reason to think that brass is not freely attacked, and even if it were, nickel-plated fittings could readily take the place of those of brass now in use.

A second scheme relates to the production of the very valuable by-product ammonia. For ammonia there seems to be a practically limitless demand. It is now manufactured in our gas works by washing the gas with water, which absorbs the ammonia. The water has been sold in many establishments as ammonia liquor. In large works, however, sulphate of ammonia is made. Sulphuric acid is placed in a large leaden pan. The ammonia liquor is pumped into a boiler and heated. The ammonia, in the form of gas mixed with steam, passes over into the sulphuric acid in the leaden pan. The process is continued until the acid is nearly neutralized. The contents of the pan are then drawn off and permitted to cool, when the sulphate of ammonia crystallizes out. The price of the sulphate varies, but may be taken as from £17 to £18 per ton. A ton of cannel produces 20 pounds, and of north-country coal about 16 pounds. The net profit got from the manufacture of ammonia may be taken as about 2s. per ton of coal carbonized.

It has been recently stated that the production of ammonia can be much simplified and reduced in cost, with the result of considerably increasing the profit to be derived from it. Extravagant assertions have been made on this subject. Thus, it has been said that gas will become the by-product and ammonia the principal article of manufacture in our gas works. This is obviously impossible, seeing that the quantity of ammonia to be had from coal is limited to a few pounds per ton; but there is every reason to believe that it is quite possible to effect certain valuable economies in this direction by the substitution of what is known as the dry process for that now in use.

Turning to another aspect of the question, there seems to be some reason to think that all that is possible has not yet been done in the way of carburetting gas. The difficulty hitherto met with has been, to a large extent, mechanical. The carbon is taken up freely by the gas, and its lighting power is very much augmented; but the gas will not "carry." It deposits its carbon as readily as it absorbs it. If this difficulty could be got over, a great deal would be gained. It is not possible that inventors who have handled the subject have given up too readily, or have not possessed the information necessary to enable them to deal with it satisfactorily? It may be found worth while to try again even schemes which have been proposed and tried several times already for producing a gas of low illuminating power—for instance, by projecting steam among burning coke, and so obtaining hydrogen. This gas might readily be carburetted up to the point requisite to make a good illuminating agent. There is, of course, nothing new in this idea.

It will be seen, from what we have said, that there are three distinct directions which inquiry may pursue, namely:—Firstly, the effect of passing the electric spark through coal gas, which undoubtedly produces acetelyne, with, it is said, an augmentation of volume and lighting power. Secondly, the production of the by-products, and especially ammonia, in great quantity and at cheaper rate than heretofore. And thirdly, the augmentation of the light-giving powers of coal gas by carburetting it. It is not too much to hope that 16-candle gas may yet be sold in London at 2s. the thousand feet. If this could be done, gas companies might regard the progress of the electric light with unimpaired equanimity. But it certainly cannot be done unless the managers of the great companies bestir themselves. Something more is wanted just now than men who can keep a great manufactory going as a paying concern. It will not do to go on forever making gas just as it was made ten years ago. The modern gas manager should be a man of invention and enterprise; his resources are practically enormous. Investigation and inquiry are essentially necessary to keep the gas manufacture in its proper place. Such men as we speak of are not lacking; knowing this, we believe that gas has still a great future.—*Engineer.*

A Peculiar Fire on a Gas Company's Premises.

A peculiar fire is now and has been raging since three o'clock Monday morning in the yard of the Mutual Gas Light Company's works. The Peninsular Iron Company's plant joins that of the Gas Light Company's near the river, and it has been the custom of the former for some time to fill in the holes and slip with cinder charcoal braize and other furnace refuse. Lately large quantities of braize were dumped there, and Sunday night hot cinders thrown in the same vicinity ignited the refuse, and the strong breeze blowing at the time fanned the flames until they set fire to the fence and sheds adjoining, belonging to the Gas Light Company. These were burned to the ground. As the earth with which the Gas Light Company's lot is filled is greatly saturated with tar, naphtha, and oils, this has taken fire and shoots up all over the premises at the most unexpected places and times, greatly resembling volcanic eruptions. A gang of men have been working night and day digging and flooding the whole place, only to find that when a new hole is dug and flooded the air rushing in causes the gases to blow another way, and again shoot up with a slight explosion, like that of a coal stove.—*Detroit Free Press*, Dec. 14.

The Petroleum Outlook.

The appreciation in prices for crude in September, (when oil went to a dollar per bbl.,) taken together with rather rich strikes in the central part of Richburg field, seem to have stimulated the drill to renewed energy. The number of wells drilling and rigs up at the 1st of November was, therefore, unexpectedly large for the season of the year.

Added to this, the production appears to have slightly increased in October, compared with the production in September. These circumstances have naturally had a depressing effect upon prices, and as a consequence we have had a comparatively depressed and declining market. These lowered prices have, however, tended to check the energy of the drillers. The cold weather will likewise have some effect in curtailing production; the Richburg field is now generally understood to be defined; and it is therefore probable that while values may continue as low as they are now, until the opening of next year's business, they can hardly be expected to decline much below the present point.

That in the Bradford field the production is slowly but surely falling off, there can be no doubt; and from the present outlook there is no other field to take its place. The Richburg field, limited and uncertain, with a thin rock and comparatively small area, cannot overcome the decline in the Bradford field more than two weeks longer, so that the coming year will, in all human probability, give us fluctuation with upward tendency, such as we have not witnessed for several years past.

There were 1,182 producing wells at the commencement of 1870, and 29,202 wells have been drilled since; 5,272 of that number were dry, and 8,230 of the producing wells have become non-productive and abandoned, leaving 15,782 producing October 1st, 1881.

At the close of this year there will be fully 18,000 producing wells against 7,096, the average number producing for the past twelve years, with an average daily production of 36,028 barrels or 5½ barrels per well.

Now if the average daily production from 7,096 wells for the past twelve years has been 36,028 barrels, averaging 5½ barrels per well, what will be the daily average production from 18,000 wells? Or can we look to decreasing production while the number of wells are increasing?—*Stowell's Petroleum Reporter.*

Reduction in Price of Gas in Washington, D. C.—On and after January 1, 1882, the price of gas will be $1.75 per thousand.

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MODAY, JANUARY 2, 1882.

Patents.

249,526. Machine for tapping mains.—David T. Hubbell.
249,528. Hot gas scrubber.—Chas. W. Isbell.
249,966. Pipe-cutting implement.—F. J. Maule.
249,968. Pipe wrench.—Timothy D. Mernan.
249,977. Pipe coupling.—Eugene F. Osborne.
250,010. Gas burner.—John H. Smith.
250,089. Illuminating apparatus.—Charles M. Lungren.
250,111. Device for heating water over lamps and gas.—Charles S. Tallmadge.
250,279. Electric gas-lighter.—Wm. R. Nutting.
250,367. Wrench and pipe-cutter.—Israel Kinney.
250,561. Gas machine.—Hiram S. Maxim.
251,085. Apparatus for the manufacture of gas.—Henry Y. Attrill.
250,668. Turbine water-wheel.—B. .H Lewis.
250,765. Box joint for sewer pipes.—J. Thompson
250,775. Apparatus for washing gases.—Wm. R. Beal.
250,793. Gas burner.—Ferdinand Dieckmann.
251,102. Gas lamp.—Heinrich W. Fabian.
251,185. Gas and oil heating stove.—Walter Carswell and James G. Miller.
251,215. Gas cooking stove and range.—William W. Goodwin.
251,329. Carburetor cylinder for air-gas machines.—Willis H. Winn.

REISSUES.

9,940. Process of and apparatus for generating gas from petroleum.—Augustin I. Ambler.
9,981. Electric gas-lighting device.—Edward J. Frost.

Death of Chas. S. Colbath.

Mr. Charles Stuart Colbath, for the past six years superintendent of the works in North Attleboro, died at the Wamsutta House Wednesday evening. Mr. Colbath was born in Boston in 1841. During his early life he was in the employ of the Boston Gas Company, and afterward was connected with the gas company at Jamaica Plain as assistant superintendent.

Gas Stocks.

Quotations by G. W. Close Jr., Broker and Dealer in Gas Stocks.
(with W B Scott & Co.,)
34 PINE STREET, NEW YORK CITY.

JANUARY 2, 1882.

☞ All communciations will receive particular attention ☜ The following quotations are based on the par value of $100 per share.

	Capital.	Par.	Bid.	Asked
Gas Co.'s of N. Y. City.				
Central	$466,000	50	70	75
Harlem	1,800,000	50	92	95
" Bonds	170,000			103
Manhattan	4,000,000	50	220	223x
Metropolitan	2,500,000	100	157	162
" Bonds	658,000	..	107	110
Mutual	5,000,000	100	85	88
" Bonds, go'd.	900,000	1000	100	104
Municipal	1,500,000	100	195	200
" Bonds	750,000		106	110
New York	4,000,000	100	109	110
Northern	270,000	50	—	100
Gas Co's of Brooklyn.				
Brooklyn	2,000,000	25	124	126
Citizens	1,200,000	20	60	63
" S. F. Bonds.	320,000	1000	105	109
Fulton Municipal	1,500,000	100	70	75
Peoples	1,000,000	10	37	42
" Bonds	290,000	.	101	104
" "	250,000	...	70	75
Metropolitan	1,000,000	100	70	75
Nassau	1,000,000	25	72	75
" Ctfs.	700,000	1000	95	100
Williamsburgh	1,000,000	50	69	72
" Bonds	1,000,000	...	98	103
Richmond Co., S. I.	300,000	50	70	75
" Bonds	40,000	—	—	—
Out of Town Gas Companies.				
Buffalo Mutual, N.Y	750,000	100	72	76
" Bonds	200,000	1000	95	100
Citizens, Newark	918,000	50	85	90
" " Bds.	124,000	—	105	10
Chicago Gas Co., Ills			125	—
Cincinnati G. & C. Co.			178	180
Consolidated, Balt.			38	39
Bonds			107	—
East Boston, Mass		25	114	120
Hannibal, Mo	100,000	100	95	100
Hartford, Conn	700,000	25	140	144
Halifax N. S	400,000	40	148	150
Hamilton, Ontario	150,000	40	117½	
Jersey City	750,000	20	155	160
Jacksonville, Ill	120,000	50	100	...
Lewistown Maine	400,000	100	—	100
Laclede St Louis Mo	1,200,000	100	108	110
Montreal, Canada	2,000,000	100	153	154
New Haven, Conn		25	132	—
Oakland, Cal			32	33
Peoples, Jersey City		...	95	100
" " Bds.				5
Pittsfield, Mass			120	130
Rochester, N. Y		50	70	80
" Citizens		100	30	35
Wilmington, Del		50	174	...
Yonkers		50	30	32
St. Louis Missouri	600,000	50	250	254
San Francisco Gas-Co., S. Fr'isco Cal.			68	69
Toledo, Ohio			95	97
Troy, Citizens	600,000	100	—	—
Washington, D. C	1,500,000	20	185	200
" Scrip	375,000	15	200	206

The following stocks were sold at auction: 88 shares Consolidated, Baltimore, at 39½; $4,400 same company's certificates, at 92; $7,000 same company' bonds, at 104½; 283 shares Brooklyn, at 123½–125; 412 shares Manhattan, at 218½; 50 shares Laclede, St. Louis, Mo., at 110½; $5,000 Laclede 8% bonds, at 105; $800 Laclede 6% certificates, at 100; 32 shares New York Gas Company, at 109½.

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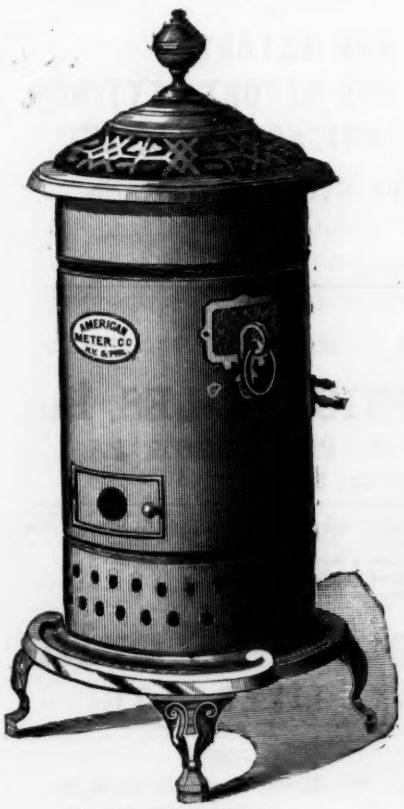

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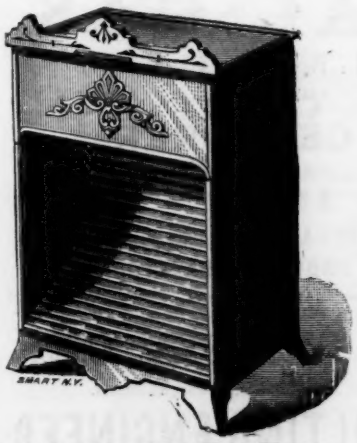

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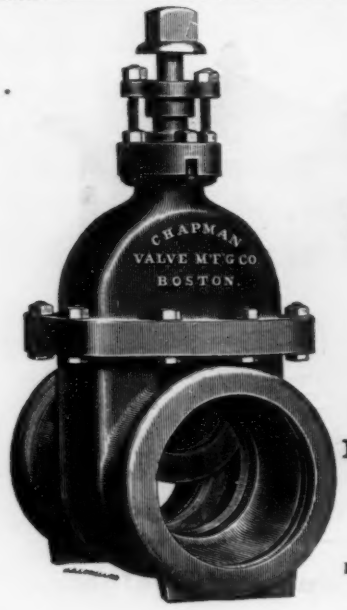

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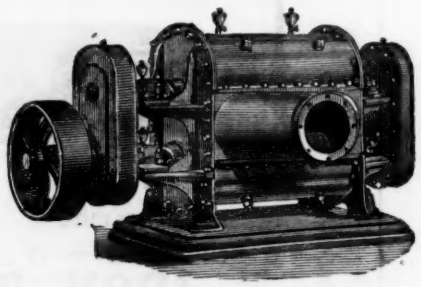

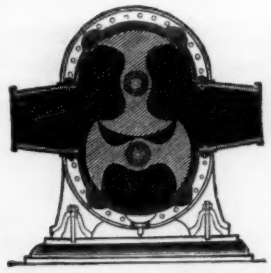

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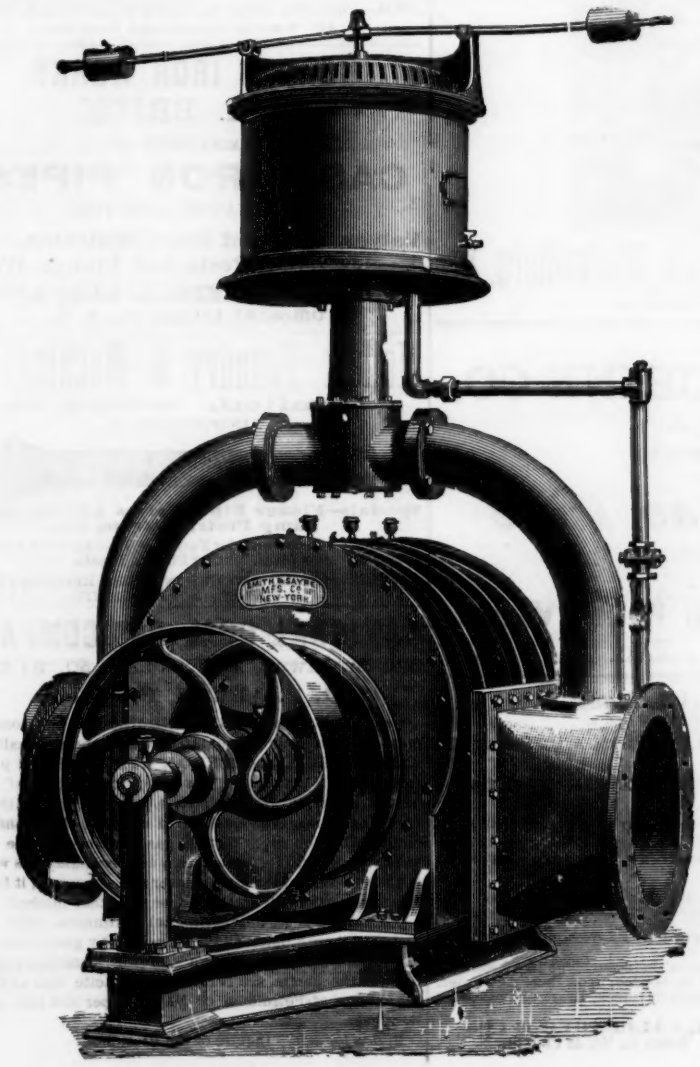

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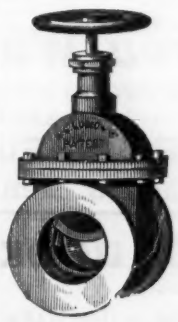

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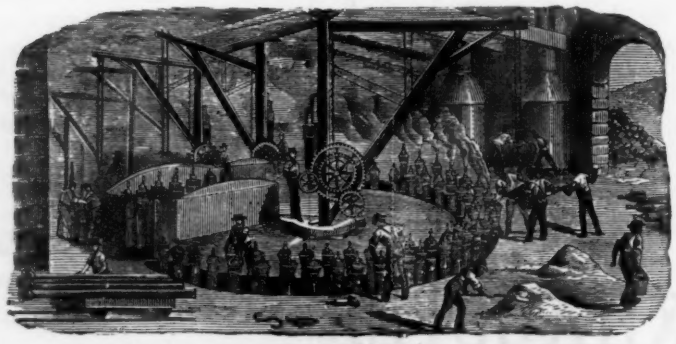

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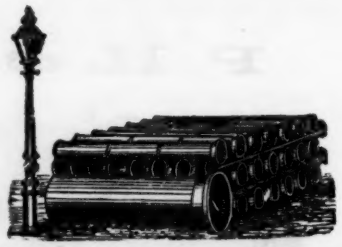

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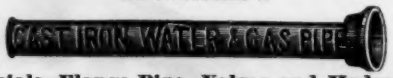

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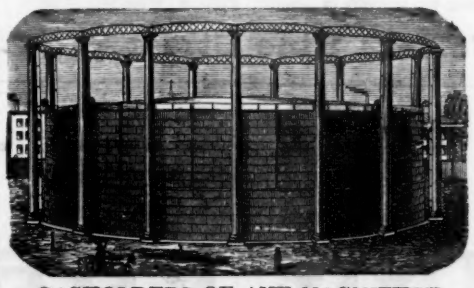

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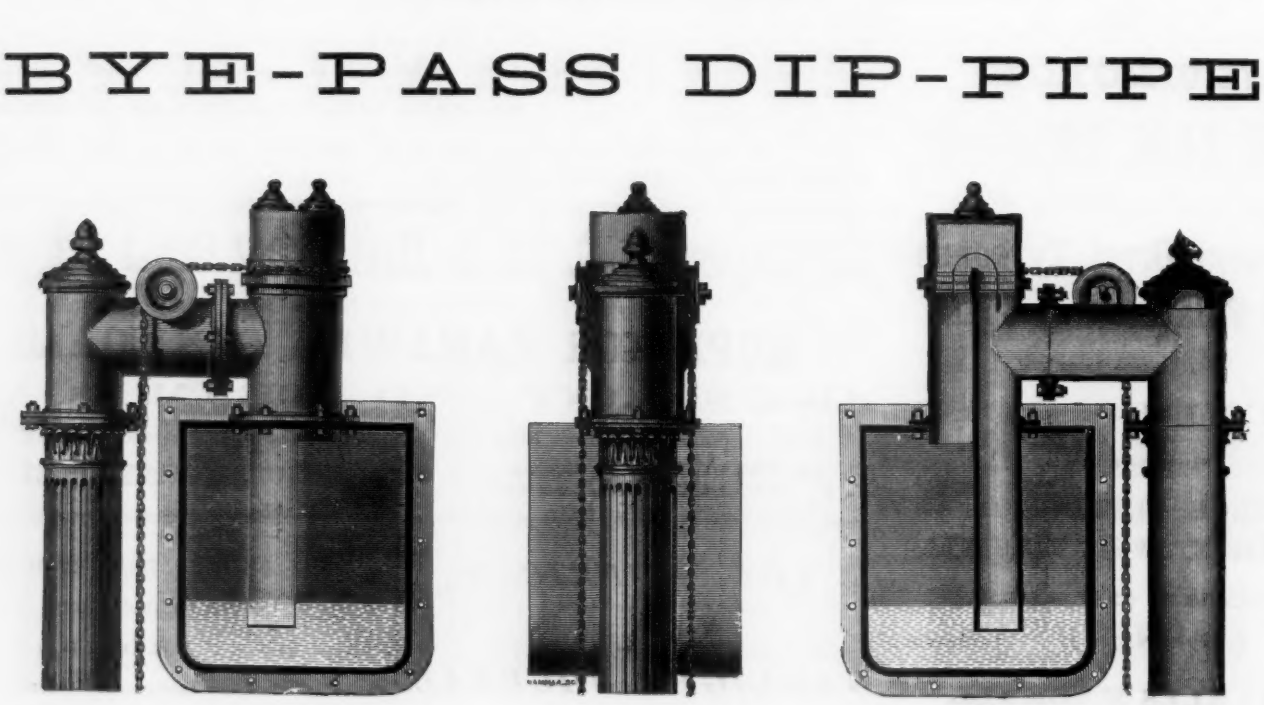

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Enables every Gas Consumer to ascertain at a glance, without any previous knowledge of the Gas Meter, the quantity and money value of the Gas consumed. Also the best method of obtaining from Gas the largest amount of its light.

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